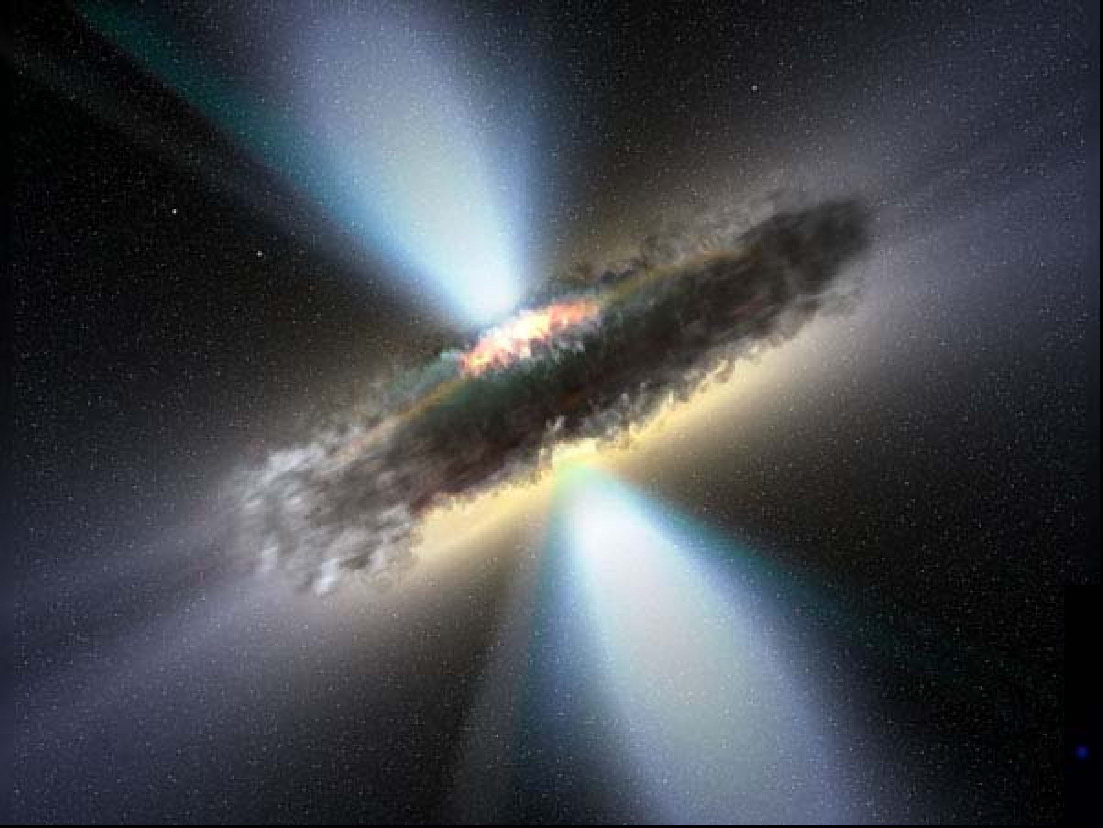
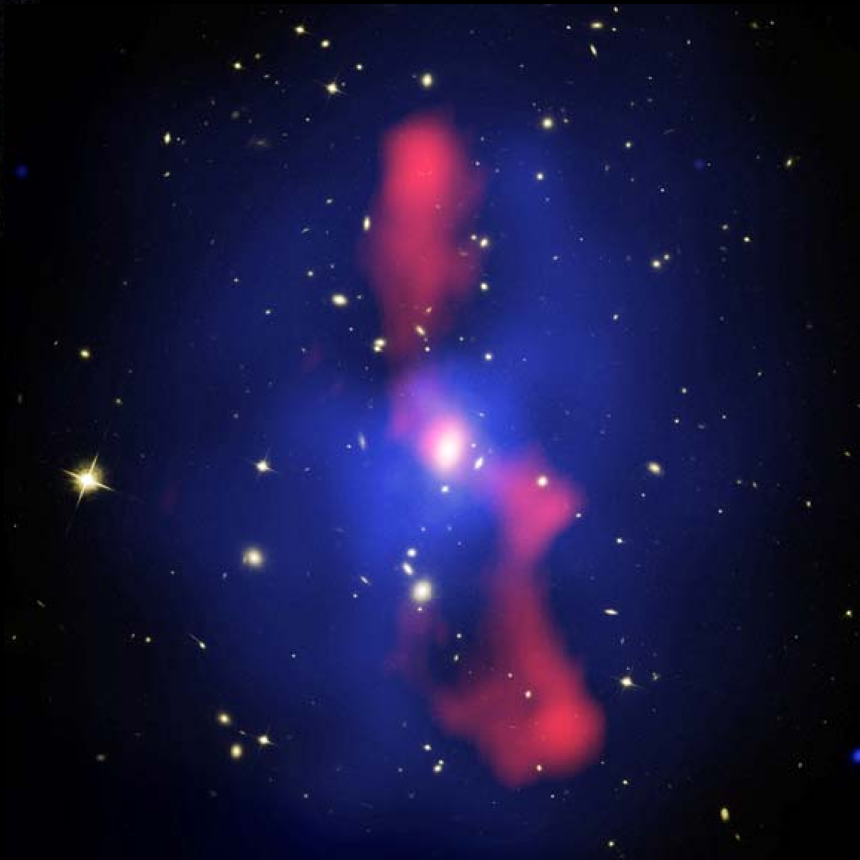


AC Fabian, G Chartas, L David
S Gallagher, S Heinz, B McNamara
E Perlman, D Proga, P Ogle,
G Richards, D Worrall

# Cosmic Feedback from AGN



# Possible effect of central black hole on host galaxy

$$E_{BlackHole} > 30 \times E_{Galaxy}$$

Energy released by growth of Black Hole

Gravitational Binding Energy of Host Galaxy

2 major modes for the interaction:

Radio (jet) and Quasar (wind/radiation)

# KEY QUESTIONS

1) Understanding the energy flow in cool cores of clusters, groups and ellipticals:

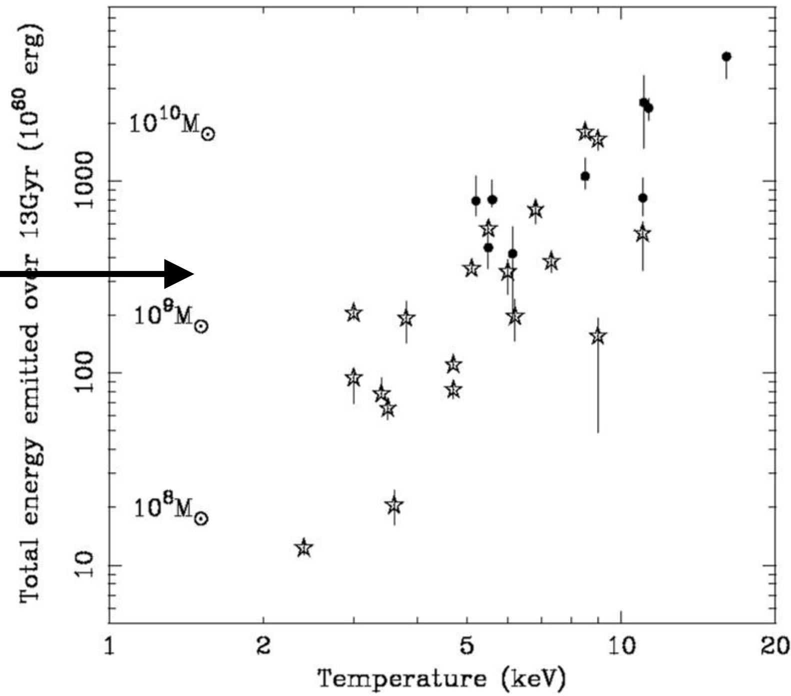
(Velocity field, bulk motions, shocks, turbulence...)

2) Understanding the energy and mass outflow of AGN:

(Mass and energy components, velocity structure, variability, ionization structure...)

# Energetics for Cool Cluster and Group Cores

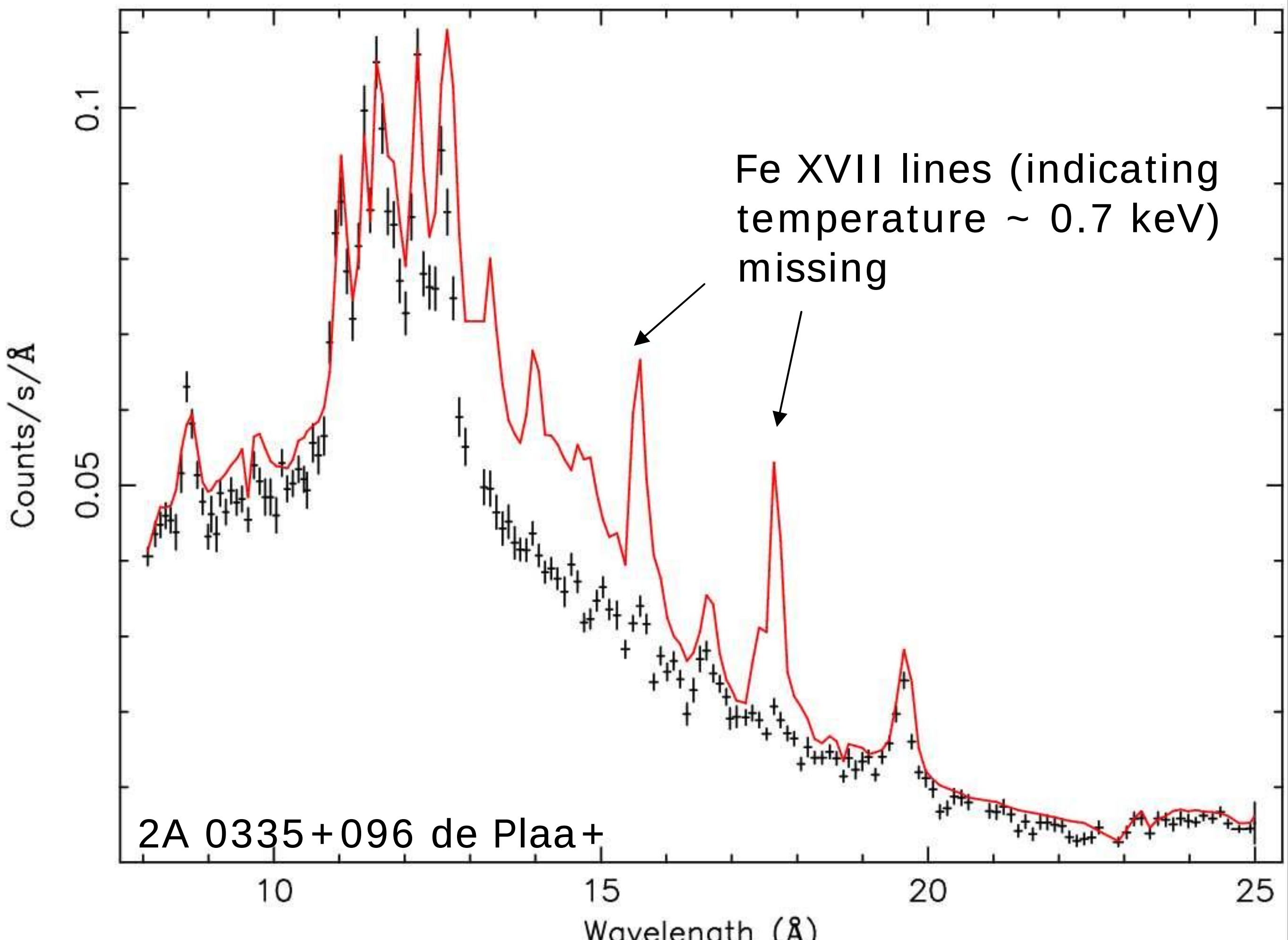
$10^{45}$ erg s$^{-1}$




Fabian+02

Most of the accretion power of central BH has to be used to heat the gas

# Lack of cool X-ray emitting gas




Slow cooling in the core of the galaxy cluster 2A 0335+096

Image courtesy of Jelle de Plaa, SRON, NL.

European Space Agency

Spectra imply less than 10% of cooling rates expected from luminosity profiles

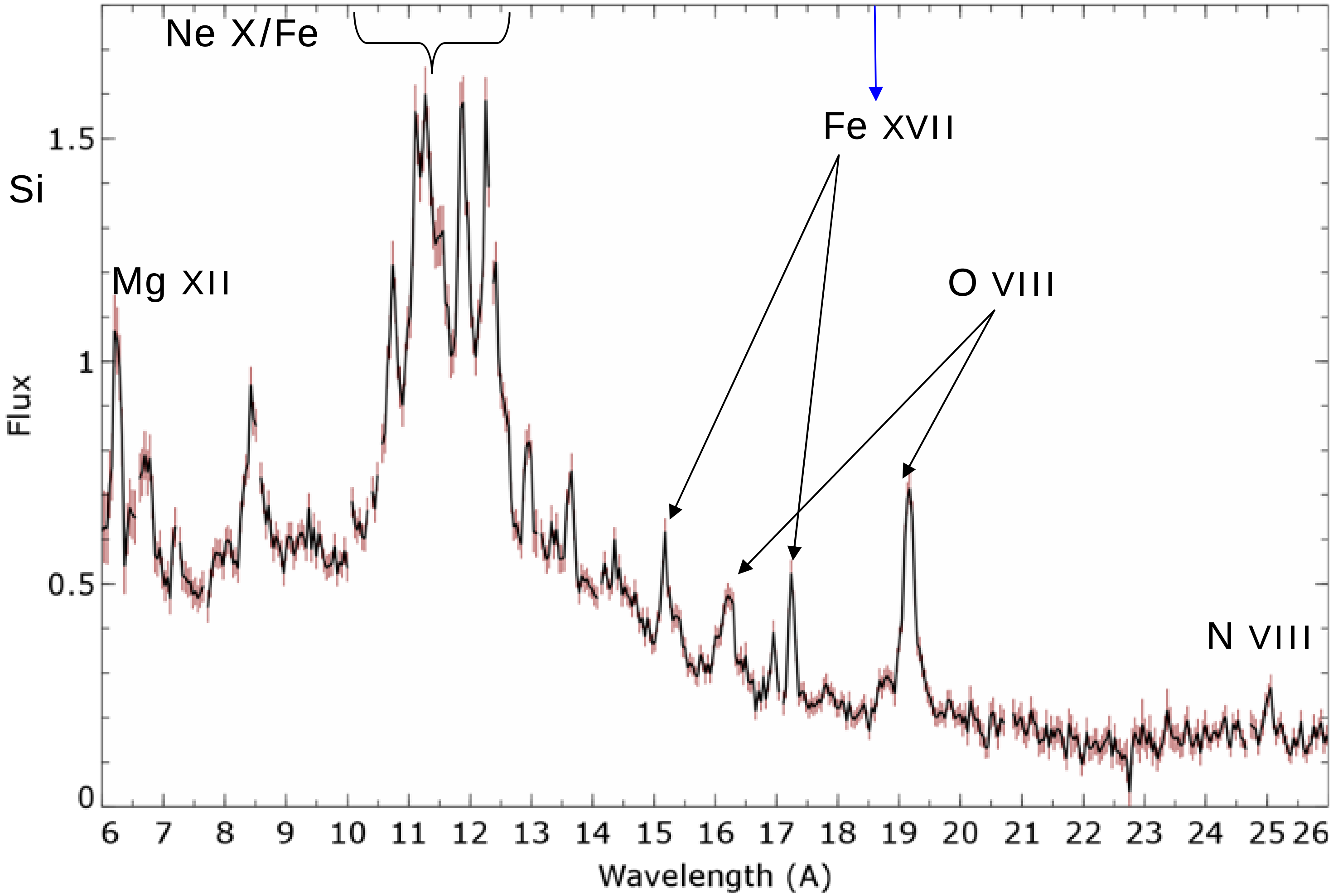
Typically temperature goes down to 1/2 to 1/3 of outer temperature

see also Peterson et al 01, 03, Kaastra et al 01, 03, Tamura et al 01,Boehringer+..

# Cool gas in the Centaurus cluster

Factor 10 temp range

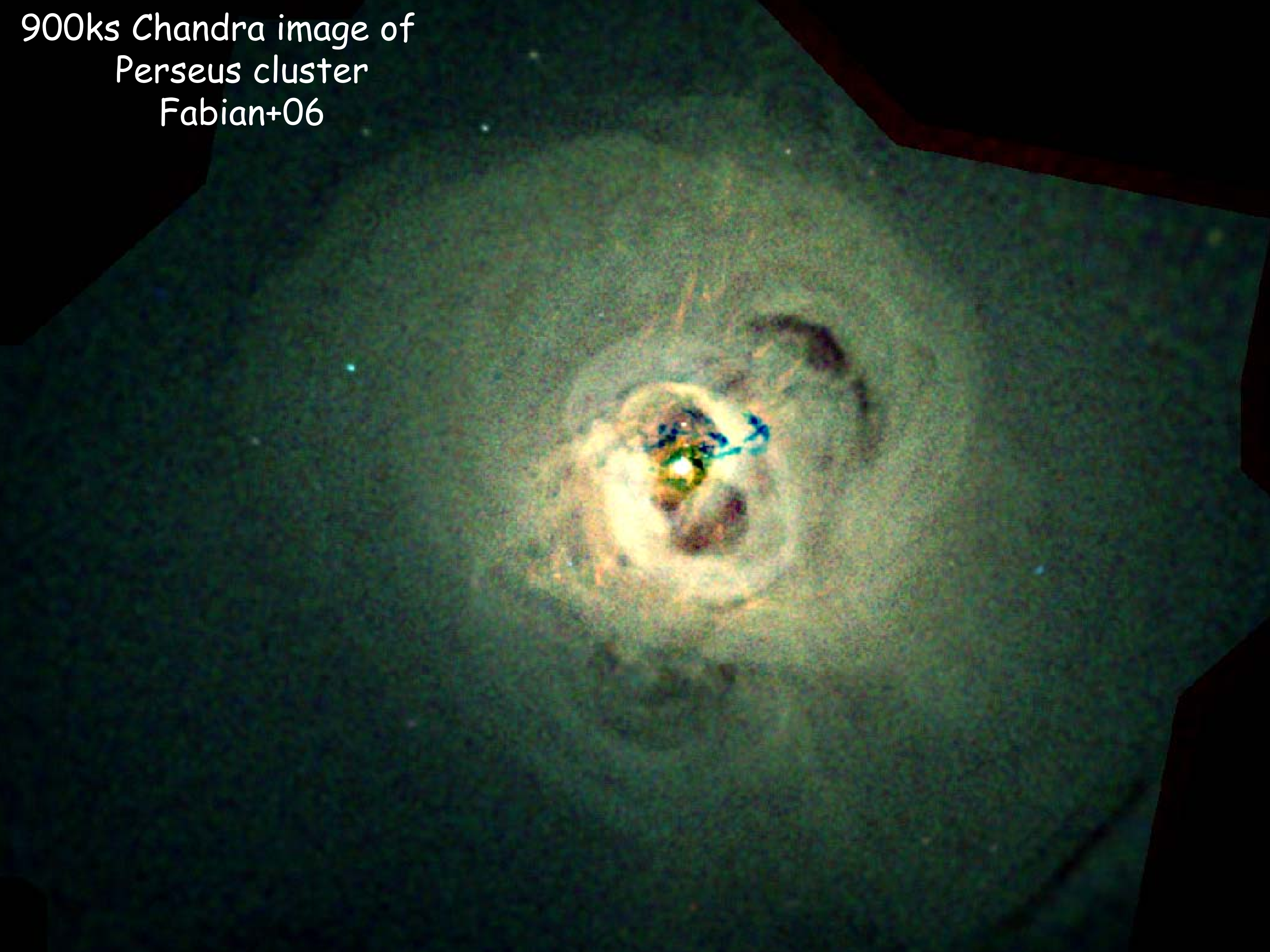
T-sensitive lines: indicate gas around ~0.4 keV compared to >4 keV in outer parts of cluster

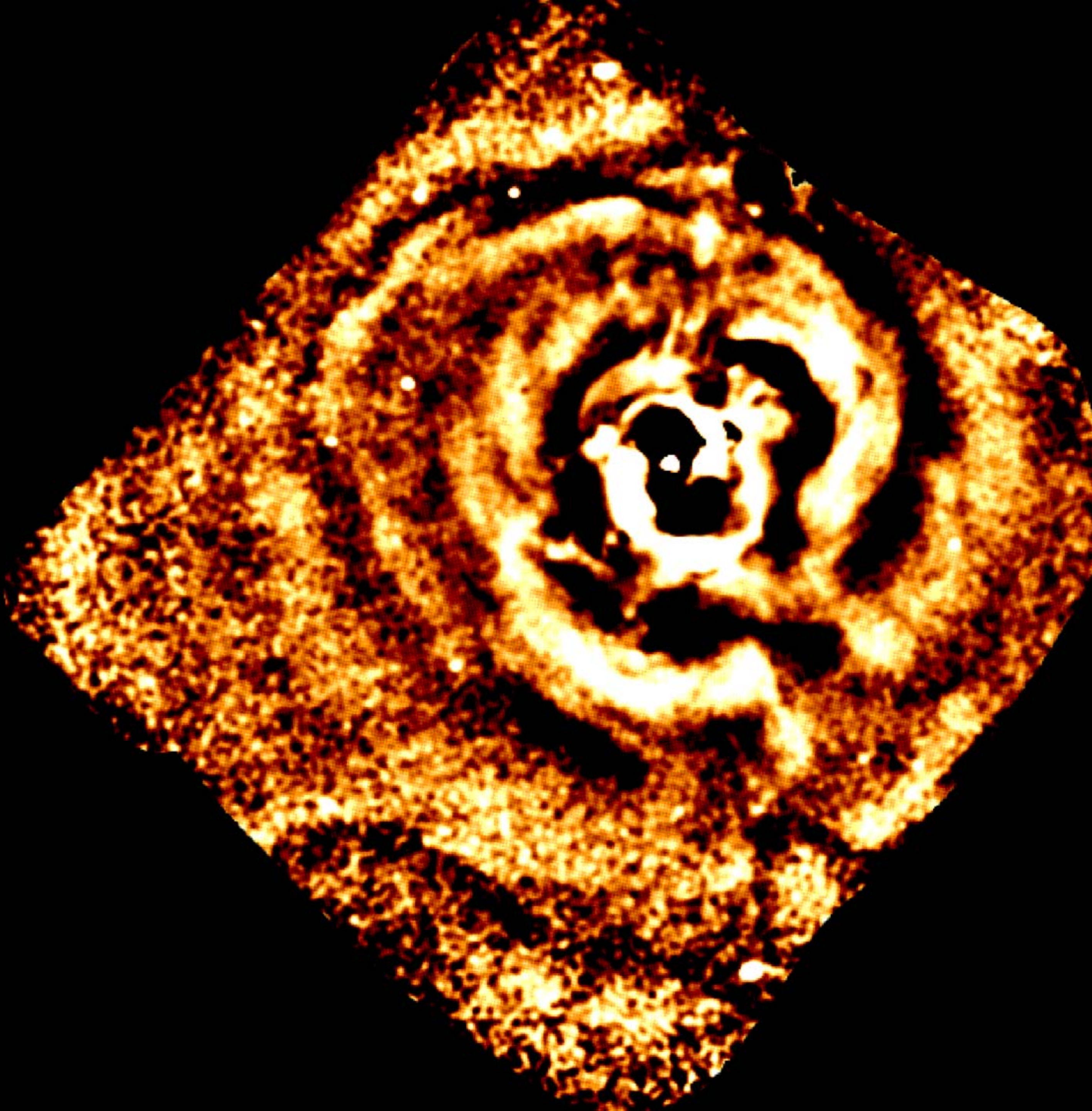



170 ks XMM-Newton RGS exposure
Sanders +07

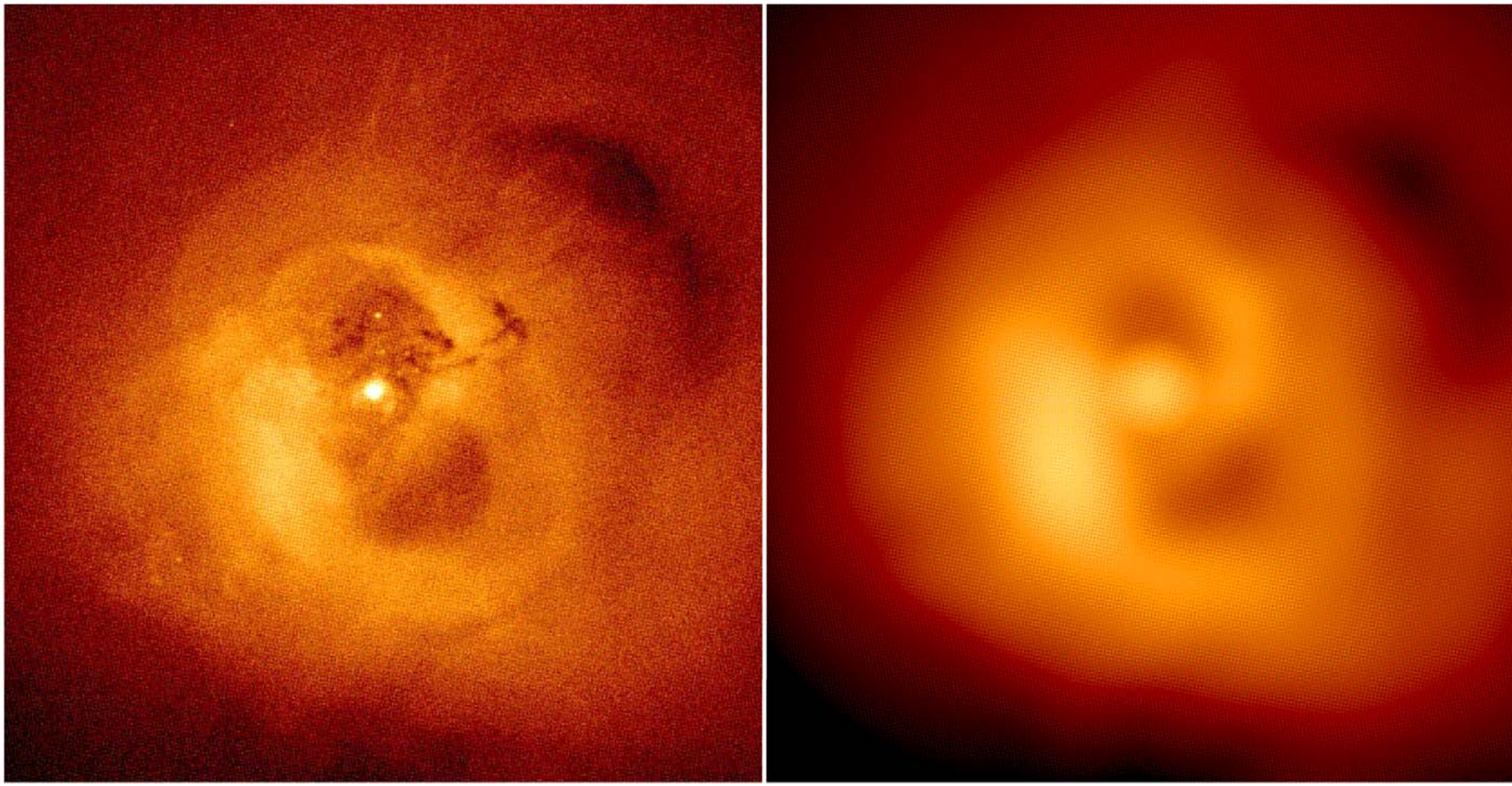
Con-X will greatly improve on such spectra

900ks Chandra image of
Perseus cluster
Fabian+06

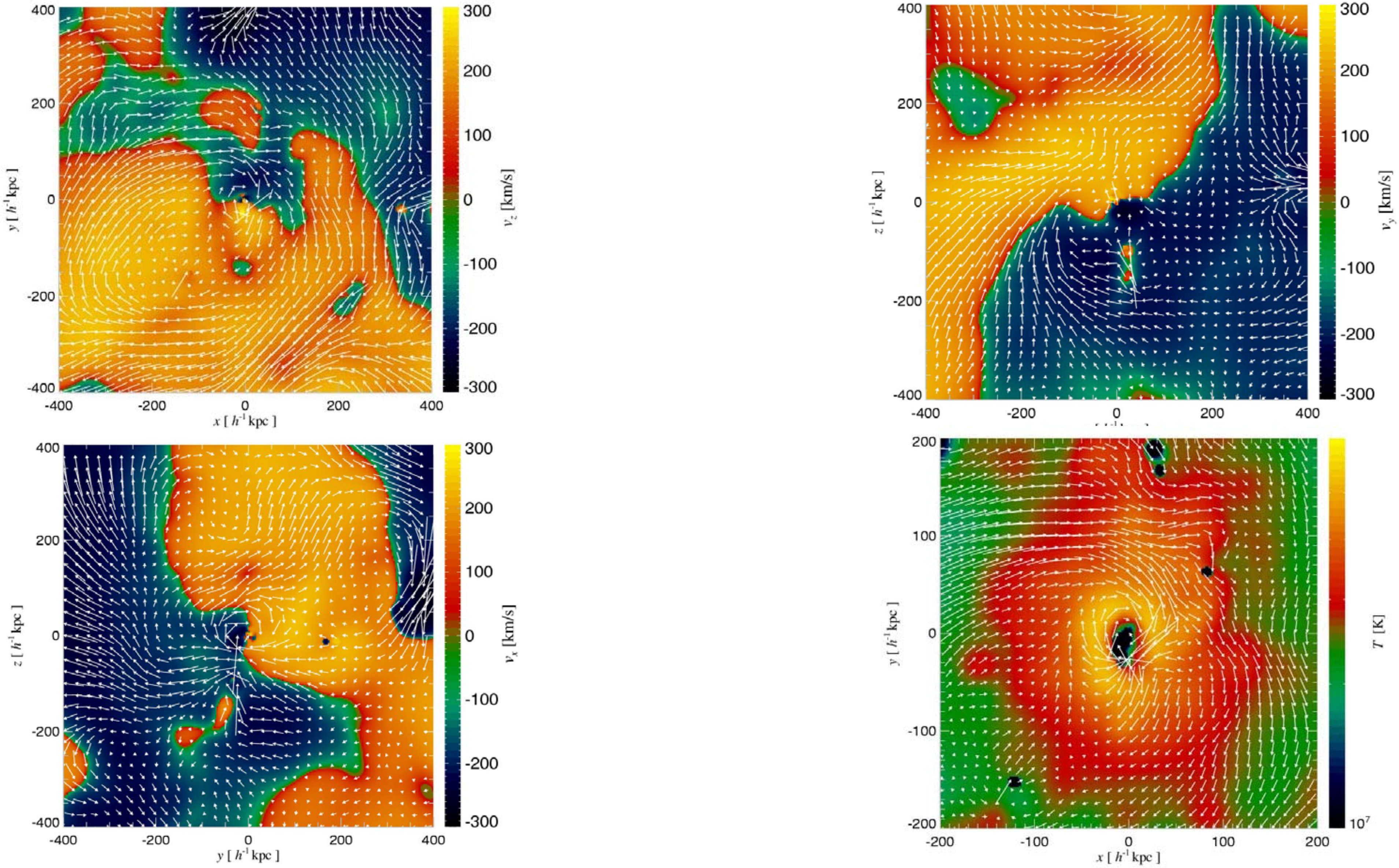


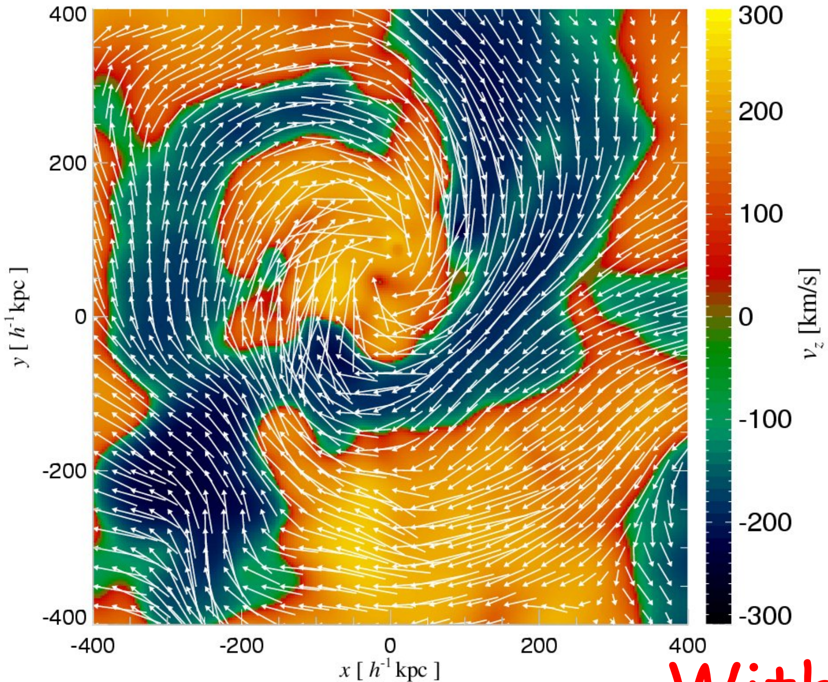


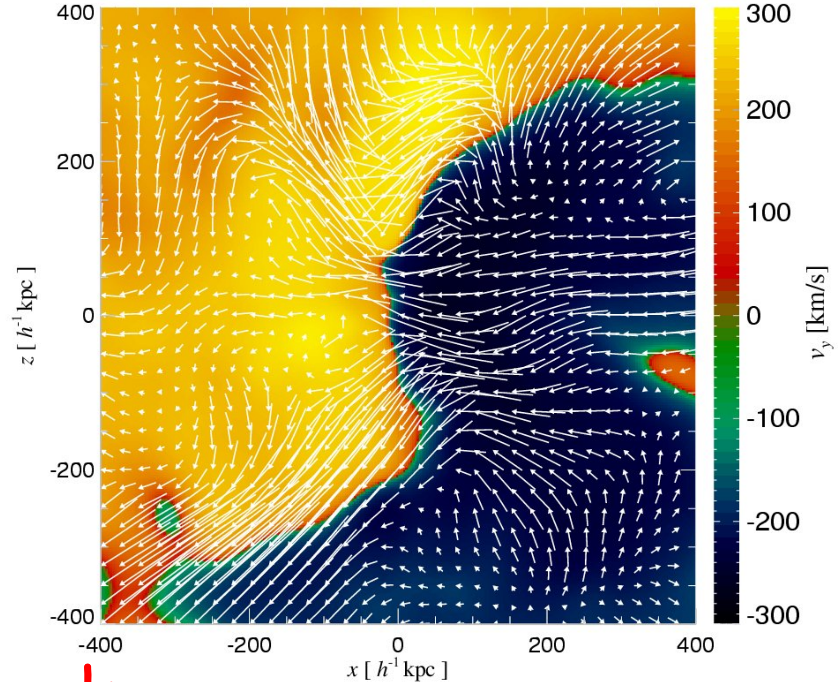
# Chandra vs Con-X



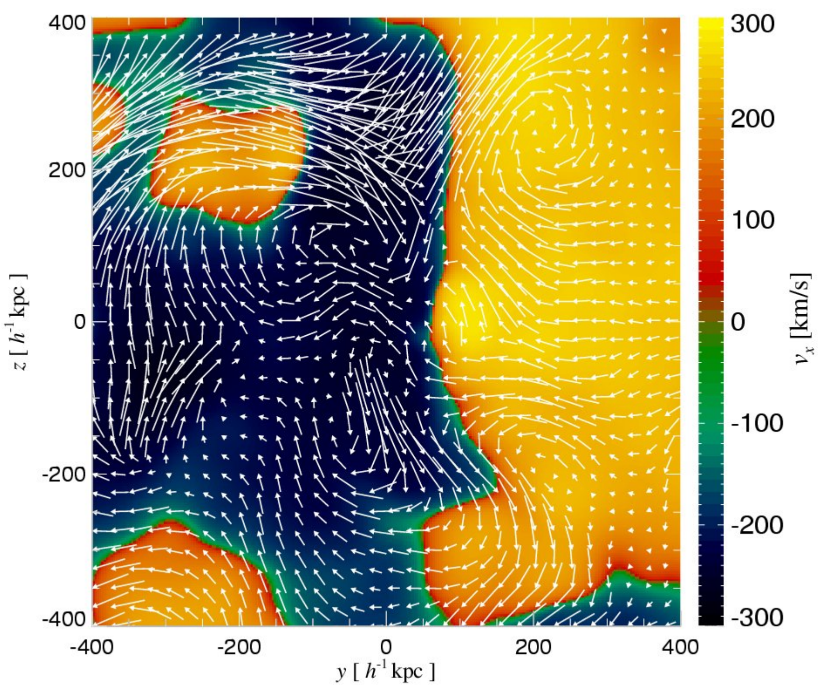
# Cluster Velocity Field with No Feedback (D Sijacki)

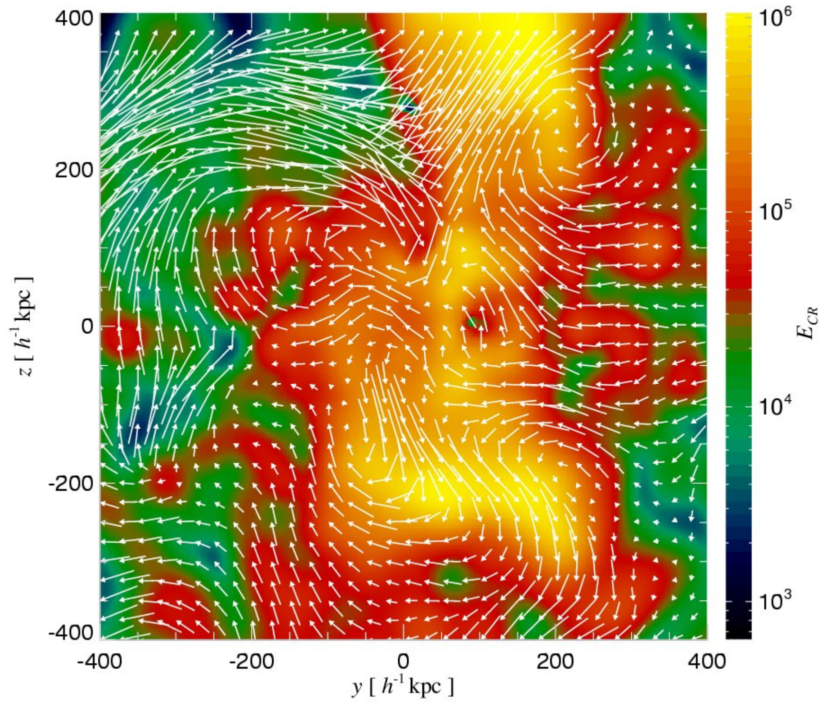


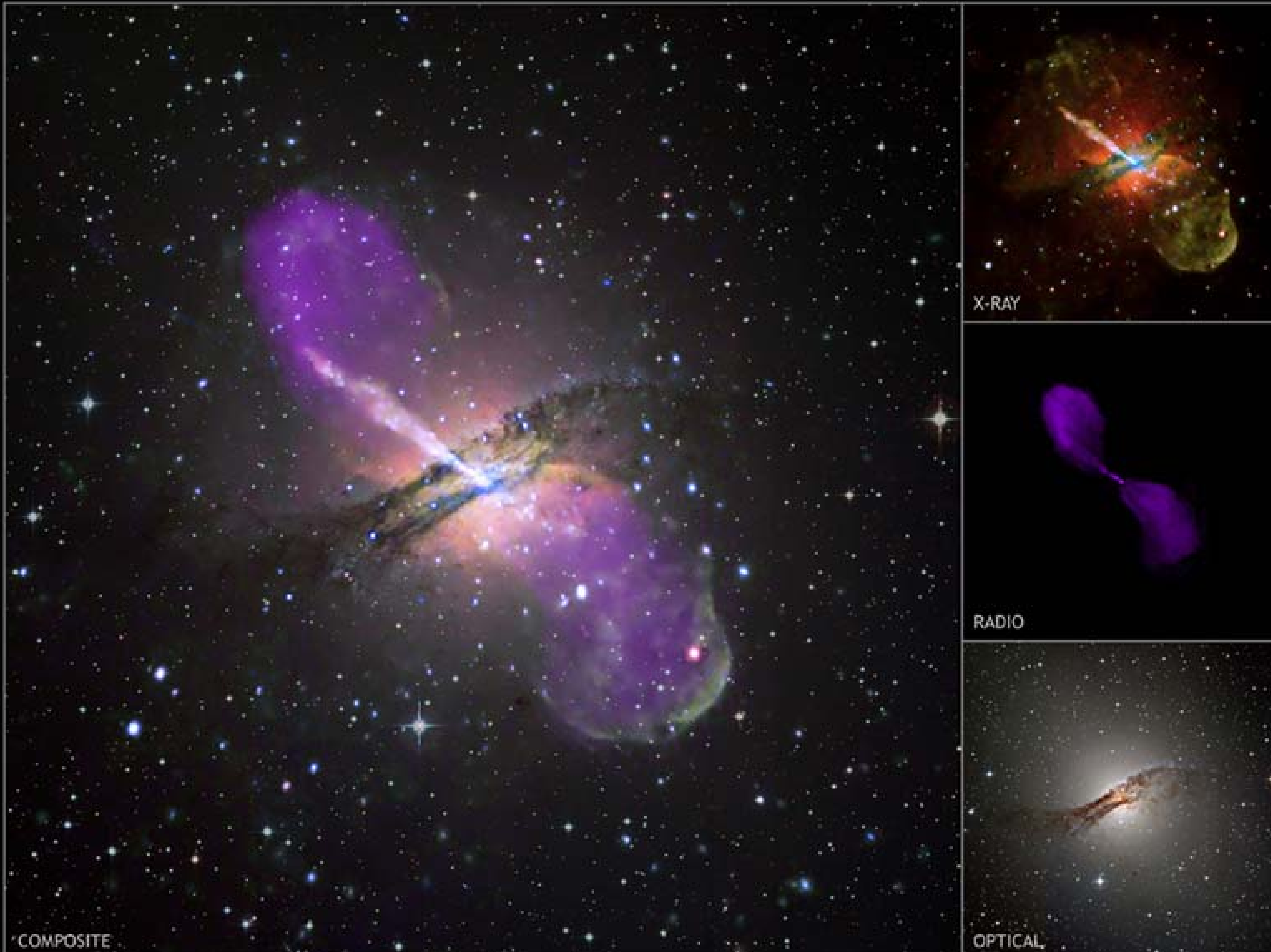


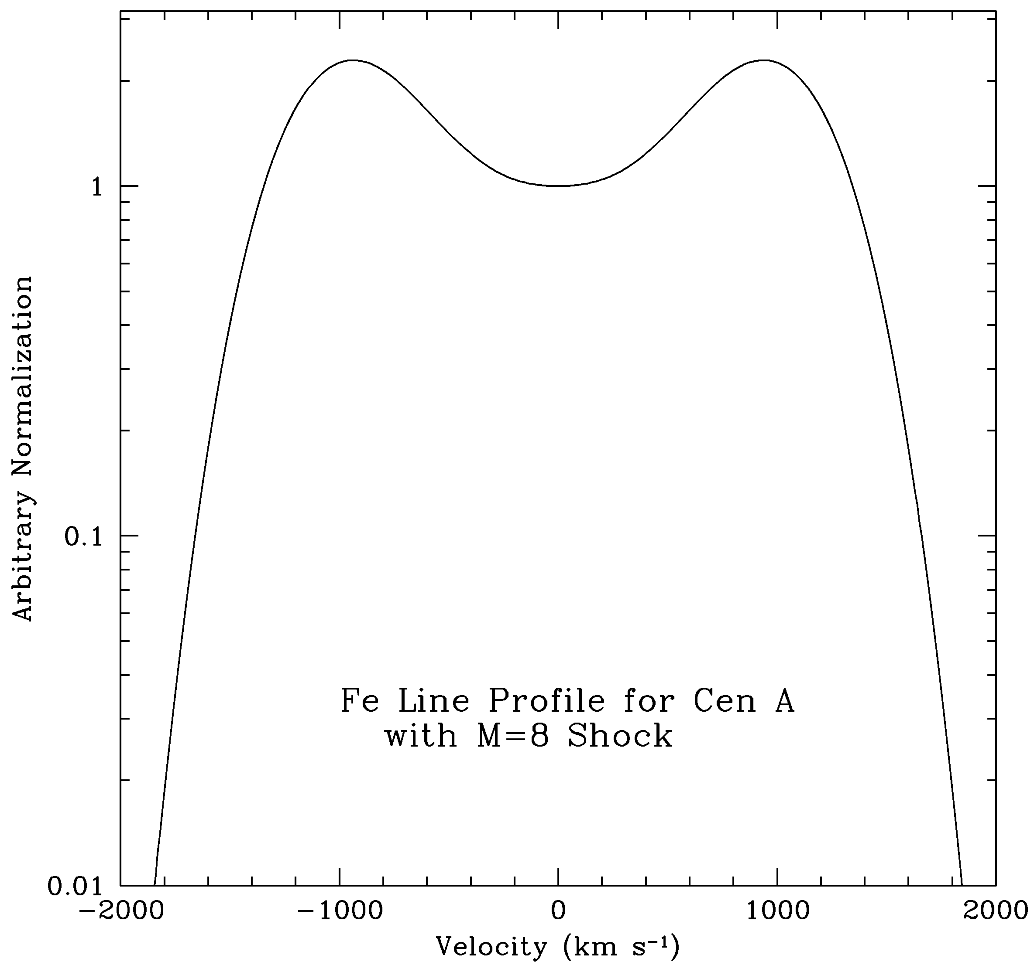




With Feedback



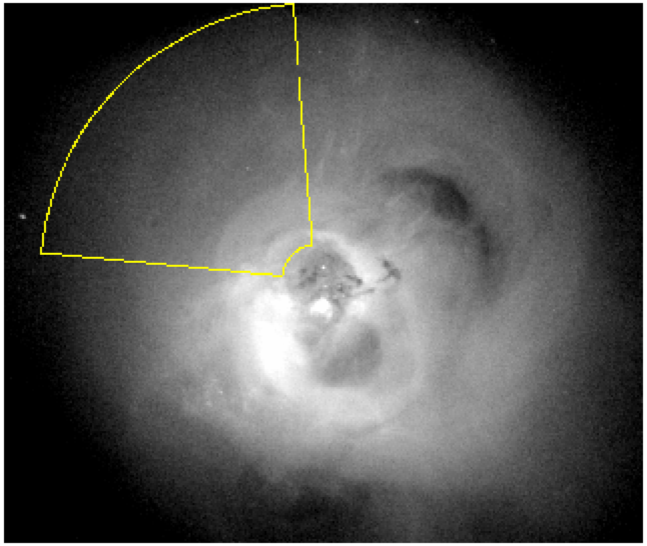

COMPOSITE
X-RAY
RADIO
OPTICAL

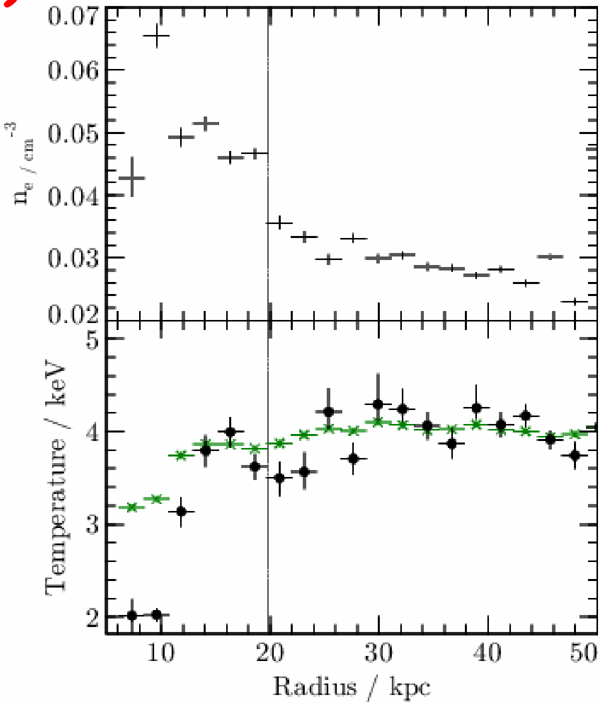


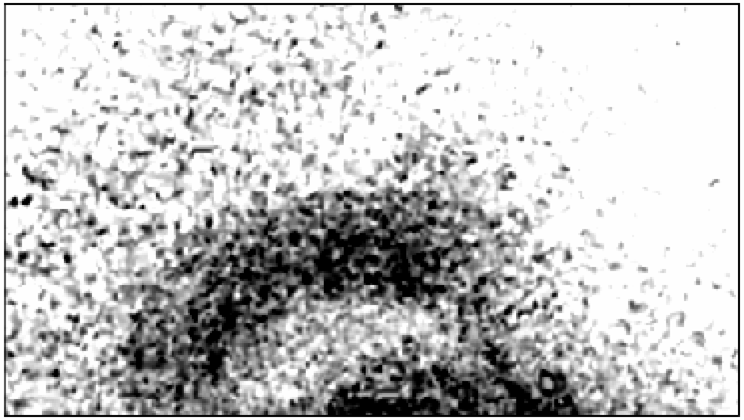
Fe Line Profile for Cen A
with M=8 Shock
Arbitrary Normalization
1
0.1
0.01
−2000
−1000
0
1000
2000
Velocity (km s⁻¹)

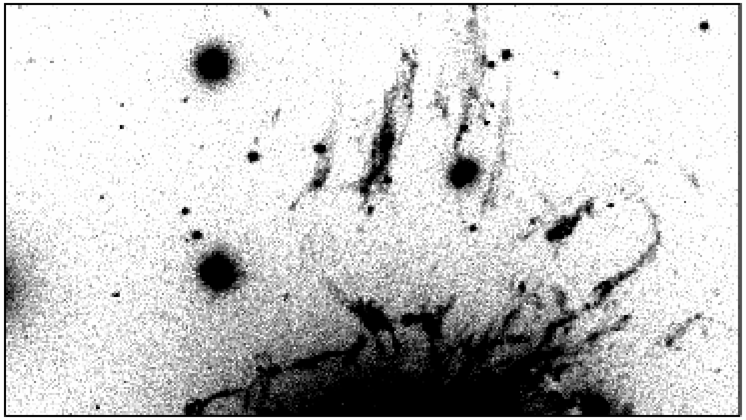
# The weak shock in Perseus

(Graham+08)



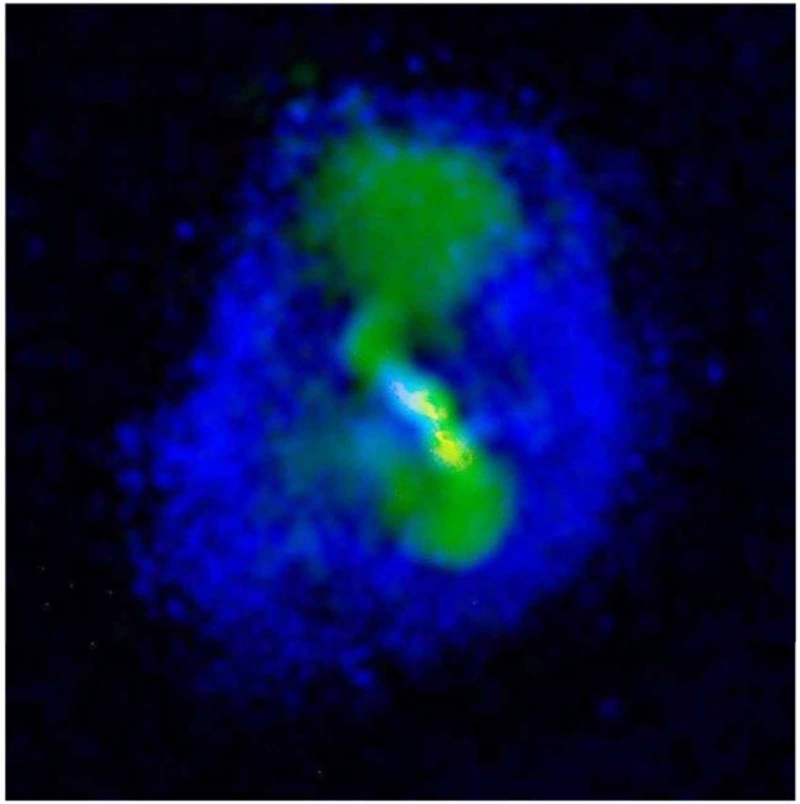


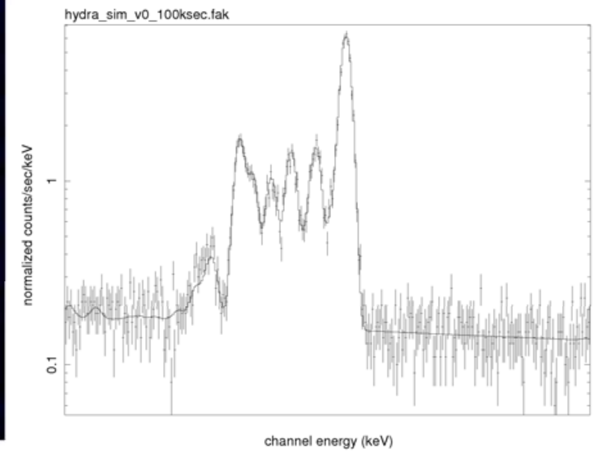



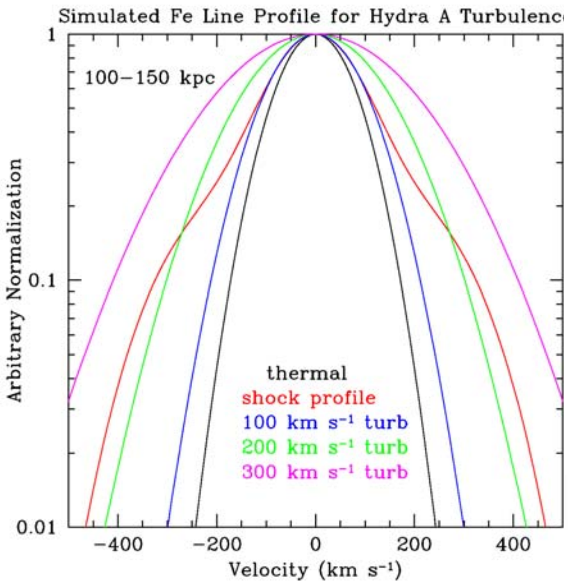


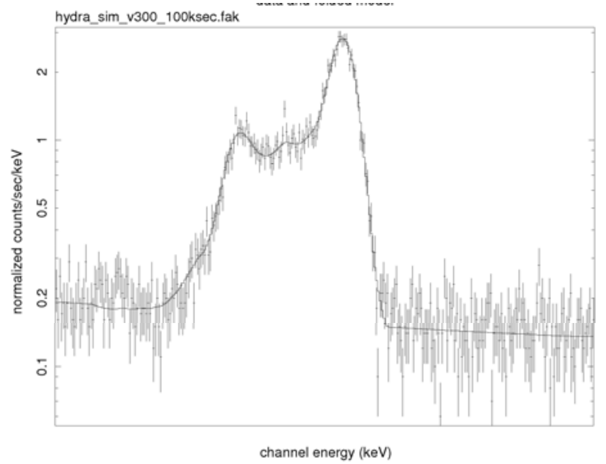
# Hydra A

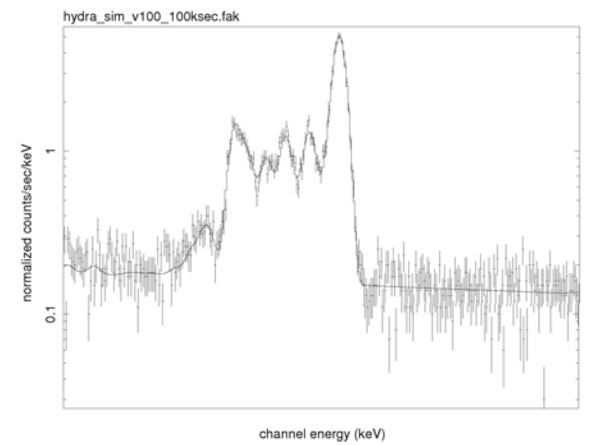
Larry David





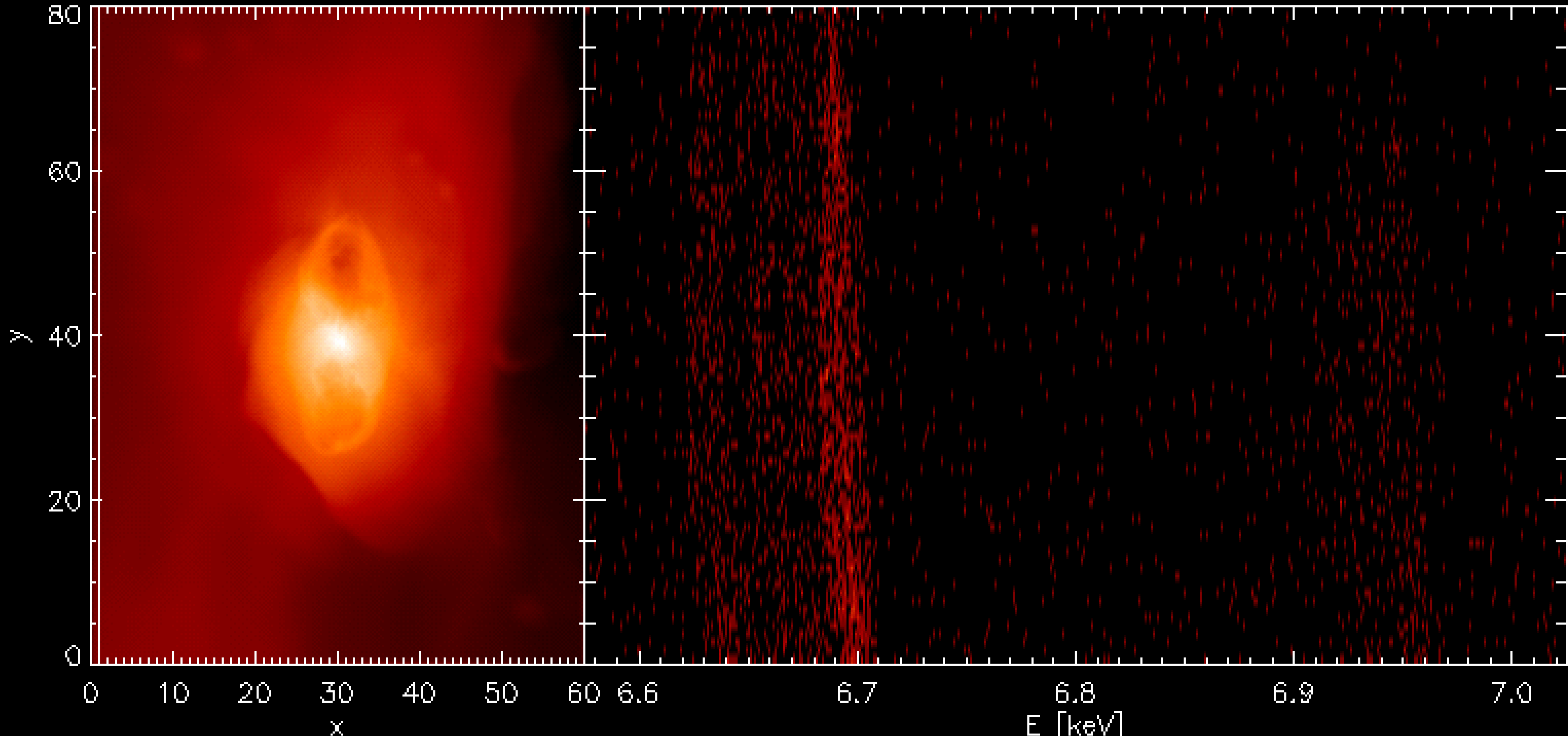



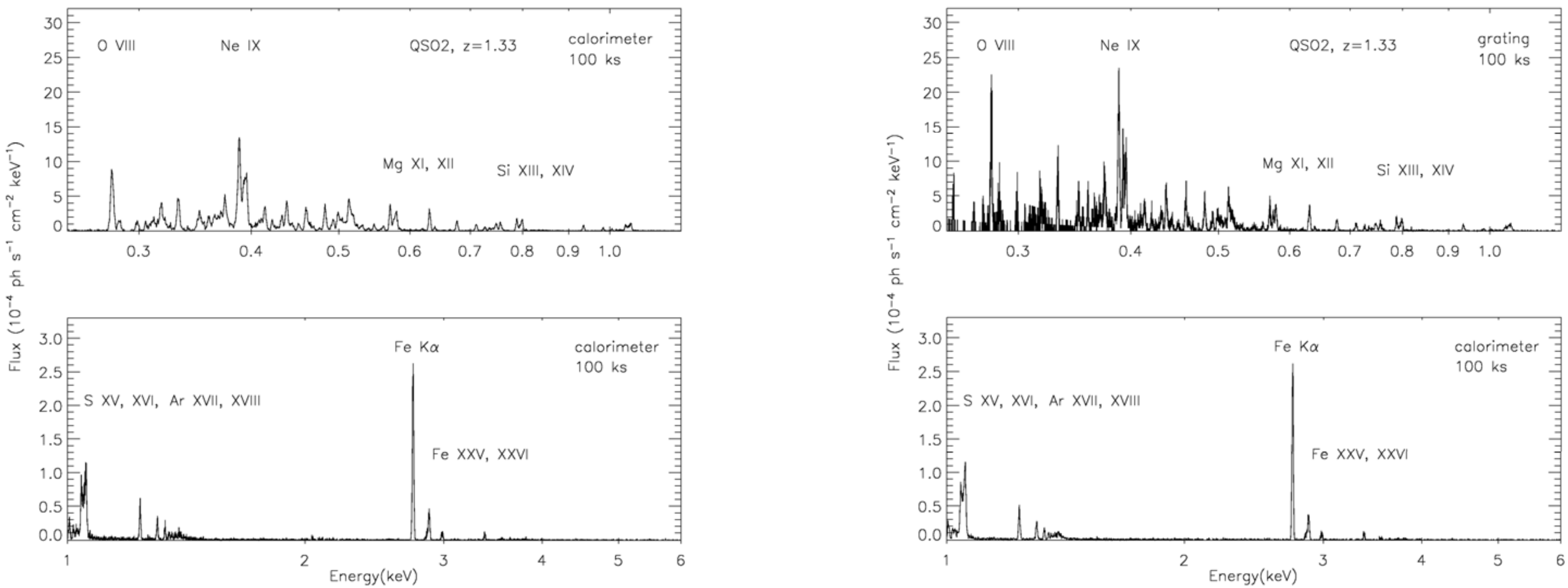



# Cyg A Iron Lines

Sebastian Heinz

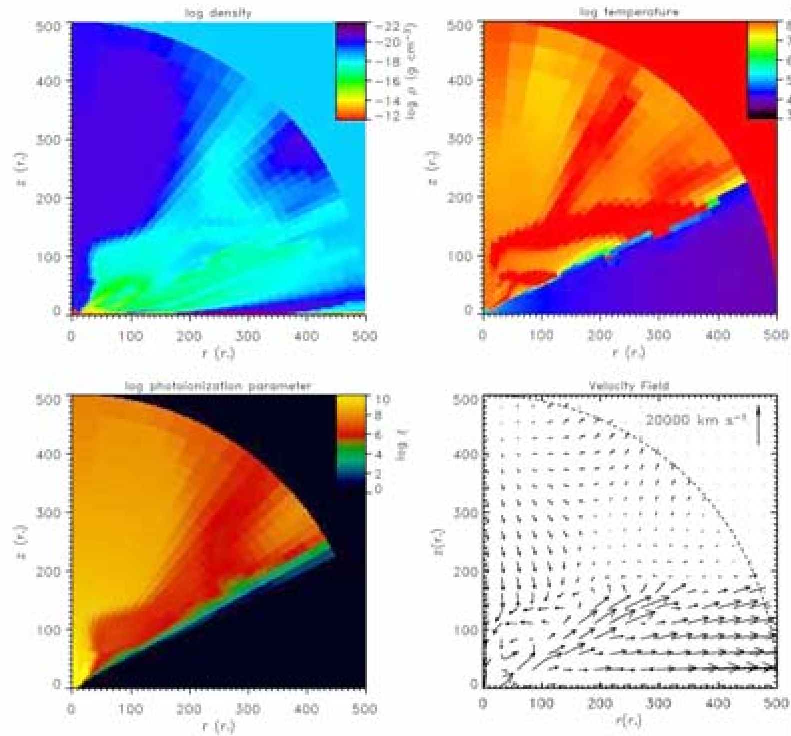


# z=1.33 Type 2 quasar similar to NGC1068 but 100 x more luminous - emission line spectroscopy (Patrick Ogle)

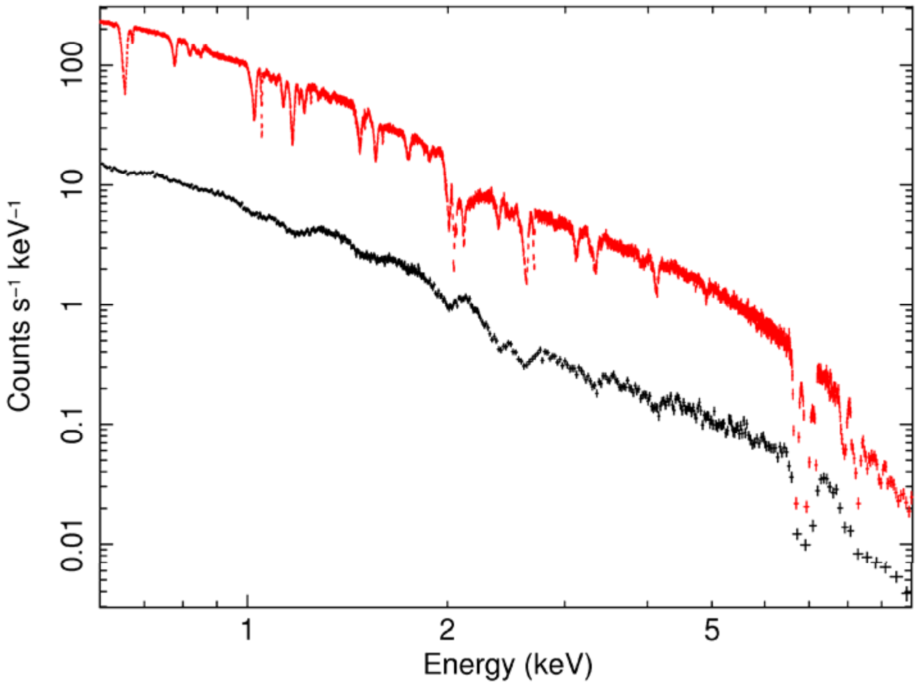


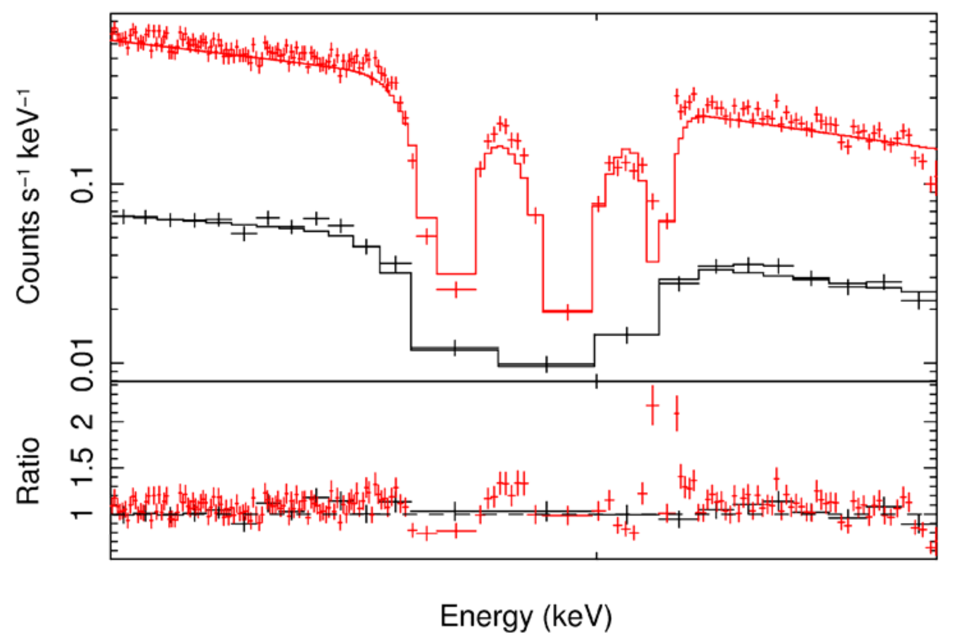
# Wind Outflow

(Model by Proga & Kallman04,
Spectrum by N Schurch,
at 62 deg)




Con-X in red, XMM in black



# AGN with reported fast outflows

| | | | v/c | |
|---|---|---|---|---|
| APM 08279+5255 | BALQSO | 3.91 | 0.2 and 0.4 | (Chartas et al. ApJ, 2002, ApJ, 579, 169) |
| H 1413+117 | BALQSO | 2.56 | 0.23 and 0.67 | (Chartas et al. ApJ, 2007, 661, 678) |
| •PG 1115+080 | BALQSO | 1.72 | 0.1 and 0.4 | (Chartas et al. ApJ, 2003, 595, 85) |
| PDS 456 | RQ QSO | 0.184 | 0.15 | (Reeves et al. ApJ, 2003, 593, 65) |
| PG 1211+143 | NLS1 | 0.081 | 0.13 | (Pounds et al. MNRAS, 2003, 345, 705) (1) (2) |
| PG 0844+349 | Sey 1 | 0.064 | 0.2 | (Pounds et al. MNRAS, 2003, 346, 1025) (3) |
| Mrk 509 | Sey 1 | 0.034 | 0.1-0.2 | (Dadina et al. A&A, 2005, 442, 461) |
| IRAS13197-1627 | Sey 1.8 | 0.0165 | 0.11 | (Dadina and Cappi, A&A, 2004, 413, 921) |
| IC 4329a | Sey 1 | 0.016 | 0.1 | (Markowitz et al. 2006, ApJ, 646, 783) |
| MCG-5-23-16 | Sey 1.9 | 0.0085 | 0.1 | (Braito et al. 2006, AN, 327, 1067) |
| MCG-6-30-15 | Sey 1.2 | 0.0077 | 0.007 | (Young et al. 2005, ApJ, 631, 73) |
| NGC 1365 | Sey 1.8 | 0.0055 | 0.017 | (Risaliti et al. 2005, ApJ, 630, 129) |

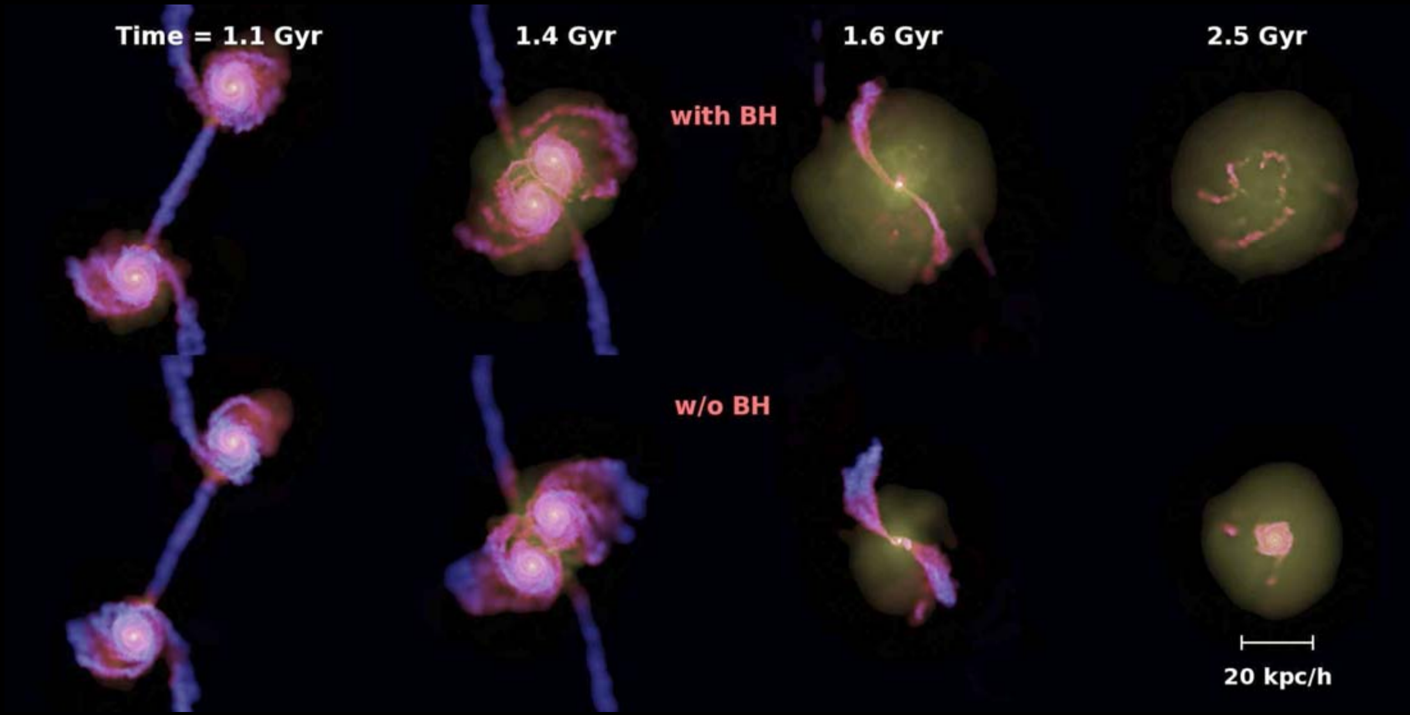
(1) Disputed by Kaspi et al., who claim the outflow may arise from a lower velocity, depending on the specific identification of lines in the spectrum.

(2) Pounds & Page 2006 (astro-ph0607099) confirm the high velocity outflow in PG 1211+143.
Reeves et al 2008 (astro-ph08011578) use a variability argument to show that the iron K shell absorption in PG 1211+143 is not due absorption from local IGM gas but is most likely associated with a fast outflow.

(3) Disputed on the basis of background subtraction in the EPIC/PN spectrum (Brinkman et al. 2005)

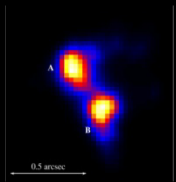
Likely that ALL AGN have outflows but influence at present unclear

# Quasar Outflows

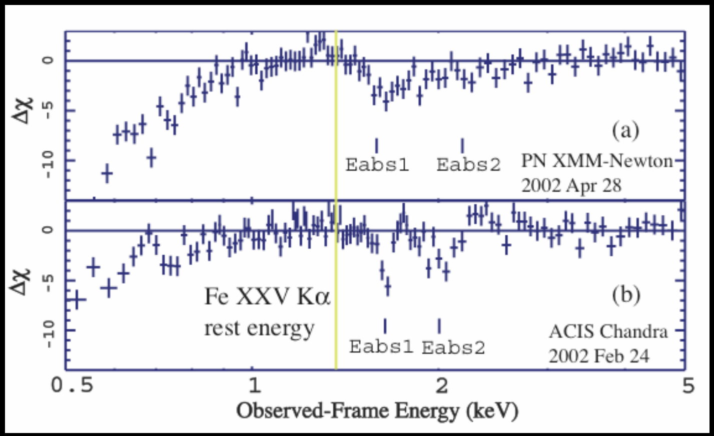



Simulations from di Matteo, Springel & Hernquist, 2005

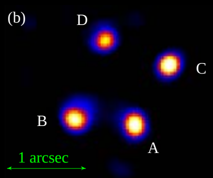
# Quasar Outflows: Observations



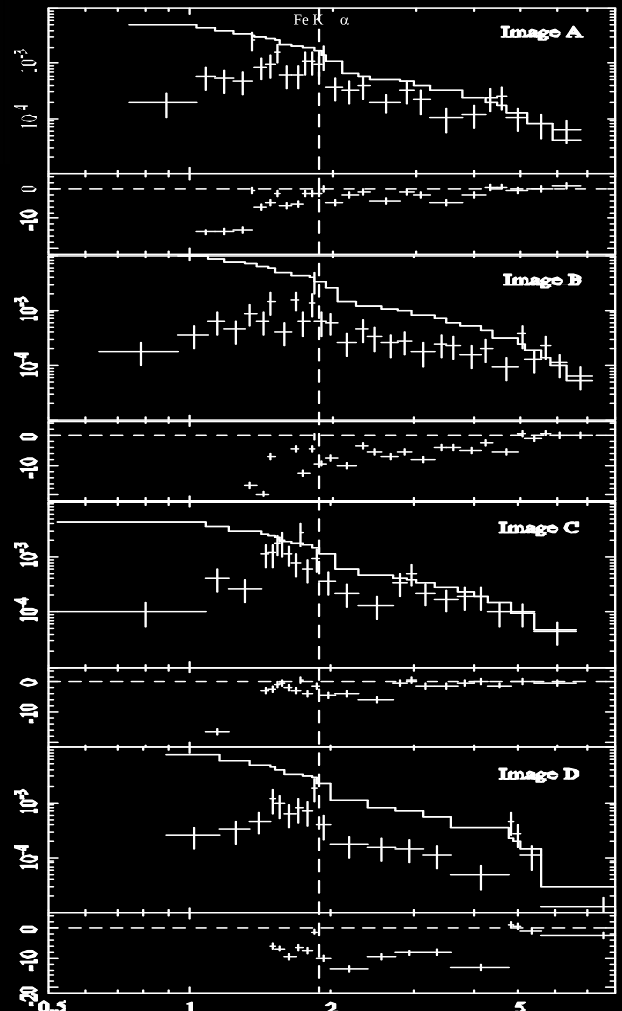

$z = 3.91$

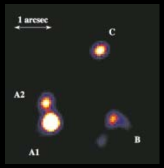



*APM 08279+5255* (Chartas et al. 2002)

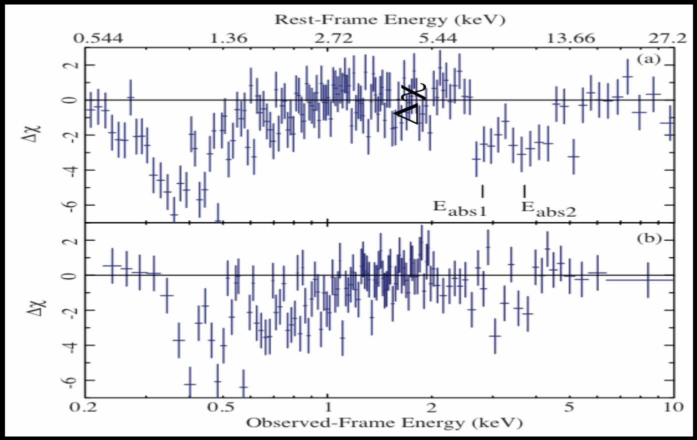



$z = 2.56$



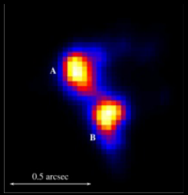

$z = 1.72$



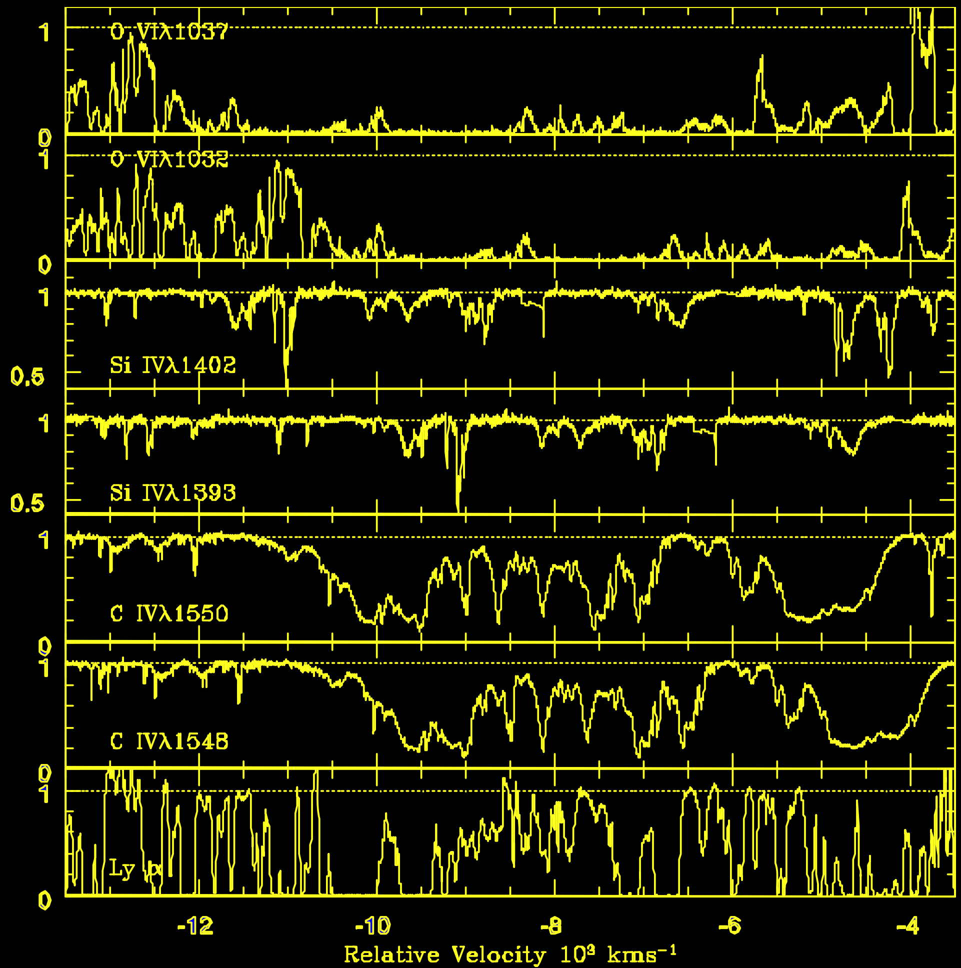

*PG 1115+080* (Chartas et al. 2003)

*H 1413+117* (Chartas et al. 2007)

# Quasar Outflows: Observations



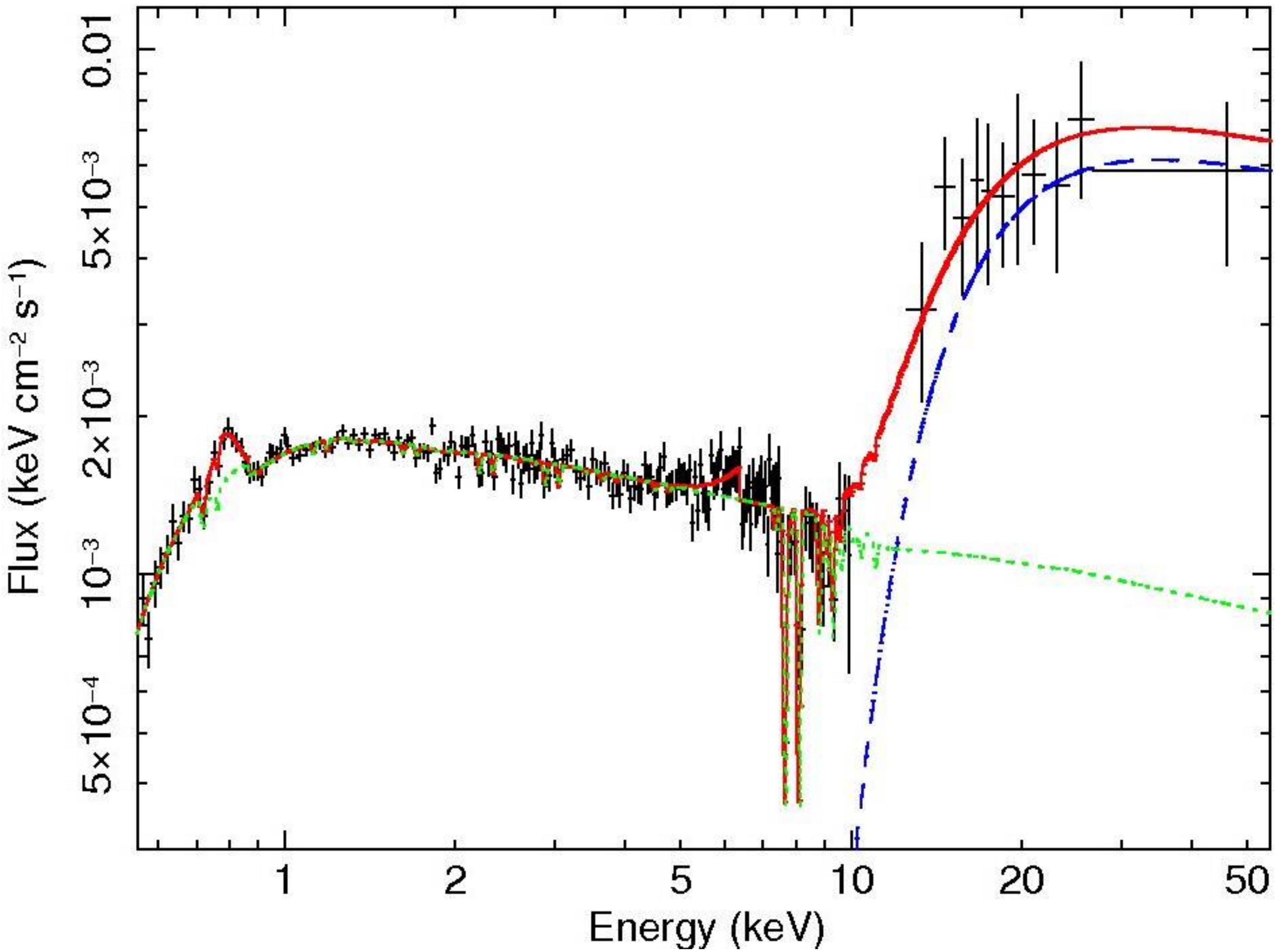

$z = 3.91$




UV BALs of APM08279+5255 due to various species. The spectrum of APM08279+5255 was obtained with the HIRES echelle spectrograph at the10m Keck-I telescope by Ellison et al. 1999.

Figure from Srianand, R., & Petitjean, P. 2000.

# PDS456 (with J Reeves+)



- X-ray absorption lines can be used to constrain the properties of quasar outflows (*$N_H$, $n_e$, $\xi$, $v$, $f_c$, $n_e$, Mdot, $\varepsilon_k$*)

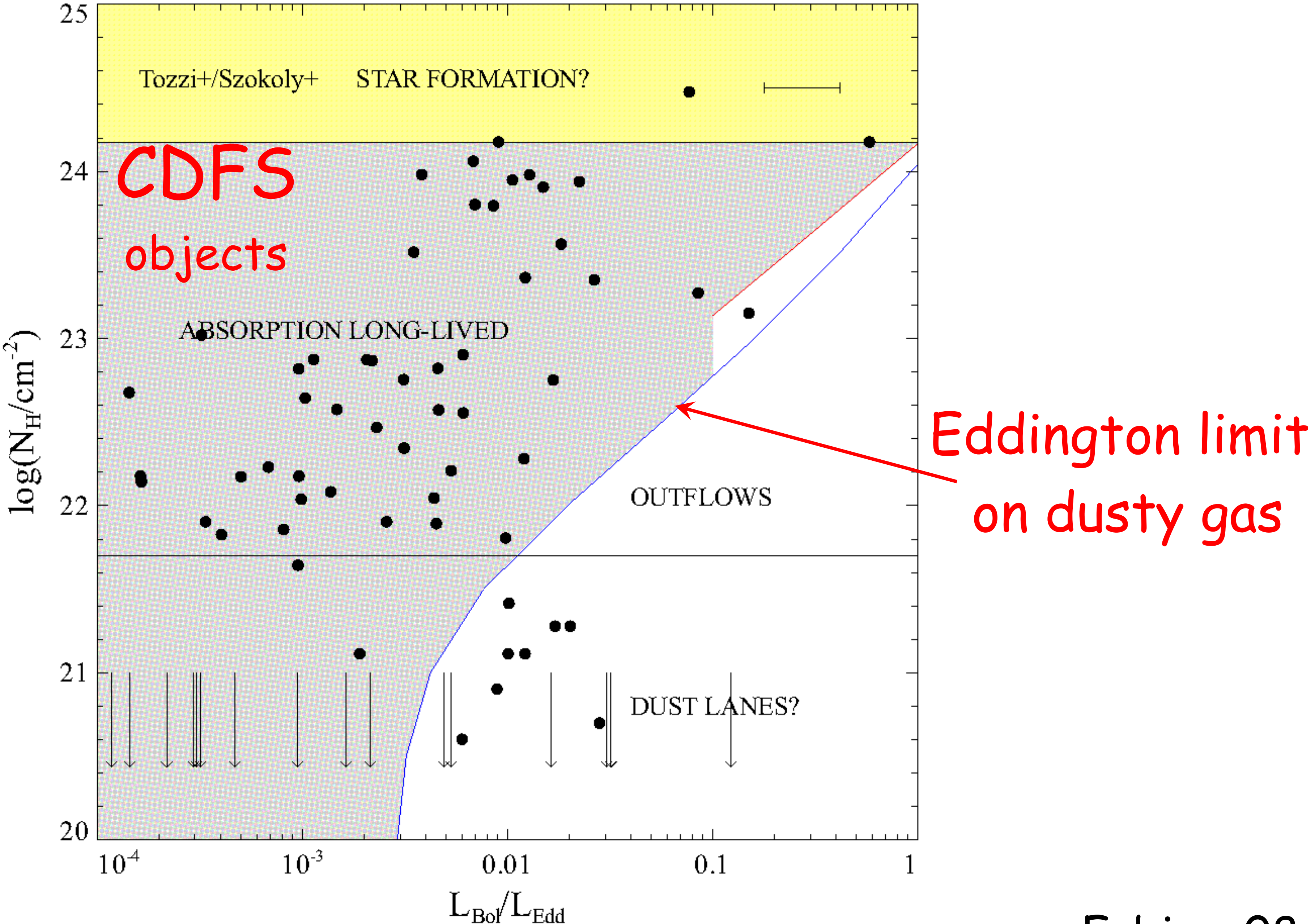
- Mass outflow rates in APM08279 (~5 $M_s$/y) and PG 1115 (~5 $M_s$/y) is found comparable to their accretion rates.

- Fraction of bolometric energy released in the form of kinetic energy

  $\varepsilon_K$ ~0.09 (-0.05,+0.07), APM 08279+5255

  $\varepsilon_k$ ~ 0.64 (-0.40,+0.52), PG1115+080

# Radiation effect?




Fabian+08

# KEY QUESTIONS

1) Understanding the energy flow in cool cores of clusters, groups and ellipticals:

(Velocity field, bulk motions, shocks, turbulence...)

2) Understanding the energy and mass flow of AGN outflows:

(Mass and energy components, velocity structure, variability, ionization structure...)

X-rays are most direct probe of crucial volume-filling component